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PF-4 SEISMIC PERFORMANCE REASSESSMENT

LOS ALAMOS NATIONAL LABORATORY

PROJECT CHARTER AND INTEGRATED PROJECT TEAM

Revision 0
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Originator

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Final Approver

Ivan Trujillo, CDNS Representative — 1/29/19

Print Name — Signature — Date

Revision Description

Rev.	Reason for Revision	Change Description	Affected Pages (Page/Sec./Para.)	Date
A	Initial Draft	Draft for Review and Concurrence	All pages.	11/7/18
0	Initial Revision	Incorporates comments from project management committee and CDNS representative	All pages	1/18/19

EXECUTIVE SUMMARY

This report presents the charter of the Integrated Project Team for conducting the PF-4 Seismic Performance Reassessment (P-SPRa) Project. The overall objective of the project is to compute the seismic performance of the PF-4 structure. The credited safety feature of the structure is to provide tertiary confinement of hazardous materials. This document highlights major tasks to be performed as part of the project. It includes a project schedule and a work breakdown structure dictionary. It also includes roles and responsibilities for key project personnel.

This document will be updated periodically as the project progresses.

Table of Contents

ATTACHMENTS

Acronyms

DBE	Design Basis Earthquake
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DSA	Documented Safety Analysis
LANL	Los Alamos National Laboratory
PC	Performance Category
P-SPRaP	PF-4 Seismic Performance Reassessment Project
PF-4	Plutonium Facility Building 4
SAFER	Structural Analysis of Facilities and Evaluation of Risk

PF-4 Seismic Performance Reassessment

Los Alamos National Laboratory

Charter and Integrated Project Team

Rev. 0

1/29/2019

1 Purpose and Objective

The purpose of this document is to define the charter for the PF-4 Seismic Performance Reassessment project. The goals and objectives of the project are defined. The roles and responsibilities for key members of the project team are presented. Schedule and deliverables are presented. Project advisory and peer review is also defined. An organizational chart is included as Attachment 1. A detailed schedule is shown as Attachment 2. A work breakdown structures (WBS) dictionary is also included in Attachment 2.

The overall objective of the PF-4 Seismic Performance Reassessment Project (P-SPRaP) is to compute the seismic performance of PF-4 in its upgraded condition. PF-4 has undergone a number of structural upgrades since about 2010. These include; 1) strengthening of roof girders with carbon fiber reinforced polymer, 2) shear strengthening of short basement columns 3) addition of seismic rattle space in basement columns that were constrained by reinforced masonry walls, 4) addition of top braces to cantilevered fire walls, 5) addition of a horizontal truss diaphragm to strengthen structural mezzanines, and 6) anchorage upgrades to a number of safety class components. The credited safety function of PF-4 in the documented safety basis is to provide tertiary confinement of contaminants in the event of an accident. Primary confinement of material at risk is provided by SDC-3 gloveboxes, and specially designed containers. Secondary confinement is provided by laboratory and vault rooms. Tertiary confinement is provided by the reinforced concrete walls, floors, and roof. Tertiary confinement is maintained per ASCE 43 as long as permanent inelastic drift in the structure is held to be less than 0.4%. Tertiary confinement would also be lost if the roof were to partially collapse due to the loss of a gravity load carrying element such as a column or roof girder.

The P-SPRaP project will compute the seismic performance of PF-4 in its upgraded condition. In order to meet this objective the P-SPRaP project includes several supporting subprojects that will feed the overall project goal

1.1 Selection of Ground Motion Levels for Risk Contribution

The objective of the PF-4 Seismic Performance Reassessment Project (P-SPRaP) is to compute the seismic performance of PF-4 in its upgraded condition. ANSI/ANS-58.21-2007 requires that for seismic probabilistic risk assessments the fragility evaluations shall be based on realistic seismic response that the components experience at their failure levels. Previous analysis have estimated median seismic fragilities for major components in PF-4 to range from about 1.85g (pga) to over 2.4g (pga) (See Table 1).

The total annual seismic risk is calculated on a component level basis as the convolution of the seismic fragility with the seismic hazard (See Section 1.5). Conceptually this convolution is simply a restatement of the theorem of total probability. The annual probability of failure is simply the probability of failure, conditional on an earthquake occurring times the annual likelihood of that event. One considers all possible events and simply sums the individual probabilities of failure.

Figure 1 shows the individual contribution of ground motions within a 0.25g bin to the total risk for a component with a median peak ground acceleration capacity of 1.85g and a composite uncertainty of 0.32. For this example one can see that the total contribution to risk for events with ground motion below about 0.50g or above 3g are negligible. Approximately 15% of total risk is controlled by events with peak ground accelerations less than about 1.0g. Approximately 50% of total risk is controlled by events with peak ground acceleration between 1.0g and 1.5g. About 28% of total risk is controlled by events in the 1.5g to 2.0g bin, with 10% of total risk coming from events larger than 2.0g.

A similar analysis will be performed early in the project to determine the range of ground motion values that are likely to control overall seismic risk. The results of that study will be presented at an early workshop. This will inform the selection of ground motion levels for nonlinear analysis to compute probabilistic seismic demand (see Section 1.3)

1.2 DEVELOPMENT OF NONLINEAR SOIL STRUCTURE INTERACTION MODEL

A new nonlinear dynamic response history analysis (NLRHA) of the PF-4 structure will be developed to generate probabilistic estimates of demand at a range of ground motion levels. The ground motion levels currently suggested are at ground motion intensities that approximate conditional probability of failure in the ranges (P_f<15%, P_f ~25%, P_f~ 55% and P_f~90%). These ground motions levels are consistent with the recommendations of the seismic expert panel (SEP) who recommended:

"*The first non-linear response should be aimed at producing a conditional probability of failure between about 25% to 30% (PF). So long as the computed PF obtained from this ground motion level lies within the 20% to 40% range, the following guidance applies. The second ground motion level should be 1.4 times the ground motion level that produced PF in the 20% to 40% range. Within my experience, the PF from this second ground motion level will lie in the 40% to 70% range. The third ground motion level should be 0.7 times the ground motion that produced PF in the 20% to 40% range. Again, within my experience, the PF from this third ground motion level will be less than 15%.*"

The range of ground motion levels suggested by the SEP will be reviewed as part of P-SPRaP including the time history development supporting project (See Section 1.6 below).

The nonlinear SSI model will provide distributions of demand on selected structural elements. The nonlinear dynamic response history analysis shall identify the other random variables that will be modeled in order to produce a distribution on response at the required ground motion levels. Random variables that shall be considered include:

1. Structural material and hysteretic damping,

2. Structural stiffness,
3. Structural mass
4. Soil properties
    a. shear wave velocity,
    b. thickness of soil layers,
    c. modulus degradation
    d. Material damping
5. Others (to be defined)

Other response parameters to be modeled as random variables may be suggested by the Integrated Project Team. The distributions, correlation, and number of random variable to be modeled shall be agreed upon by members of the Integrated Project Team and the Independent Peer Reviewers prior to the initiation of work. Sensitivity studies are planned early in the project phase to identify which random variables loss of confinement is most sensitive to. Variables which have little influence on loss of confinement may be modeled as constants.

The structure model shall be sufficiently detailed to provide component-level demands (shear, moment, displacement demand) on critical structural elements deemed to control the overall global structural fragility affecting confinement functionality.

Development of the nonlinear SSI model will be led by a collaboration between SC Solutions (Ben Kosbab) and Idaho National Engineering Laboratory (Robert Spears). Assisting in the development of the nonlinear soil-structure model will be technical staff members from Los Alamos, INL, and SC Solutions.

1.3 Computation of Probabilistic Demand

Probabilistic demands to account for both structure uncertainty, soil uncertainty, and variability in ground motion will be obtained via numerical simulations at the range of ground motion levels described in Section 1.1 and Section 1.2. It is currently expected that a minimum of 30 latin hypercube simulations at each ground motion level will be performed to allow for definition of a cumulative density function of demand, conditioned upon ground motion.

The simulations will be performed using either the nonlinear soil structure interaction model developed in the modeling phase, or a fast running surrogate model that has been benchmarked against the validated three dimensional SSI model to produce demand quantities of interest.

From previous fragility analysis[1] the controlling structural elements and associated failure modes are as shown in Table 1. The table presents the median factor of safety above the demand for a 0.47g pga event ($4x10^{-4}$ annual frequency of exceedance), with corresponding composite uncertainty. The pga ground motion levels that correspond to other conditional probabilities of failure are also given. For example, there is about a 10% probability of shear wall failure given a ground motion input of 1.23g and

[1] Carl J. Costantino and Associates, "PF-4 Nonlinear Analysis and Fragility Evaluation," for Los Alamos National Laboratory, Document ID CJC-PF4-010, Rev.1, Spring Valley, NY, September, 2013.

a spectral shape matching the UHRS. Structural demand in terms of shear, moment, axial load, and drift will be needed at each of the shear wall locations, column locations, girder locations, or floor slab locations in order to compute a probability of failure at each ground motion level.

Table 1 - Ground Motion Levels for Nonlinear Analysis of PF-4[2]

Failure Mode	Median FS	β_C	Ground Motion Levels (pga)		
			10%	40%	70%
Shear Walls	3.94	0.32	1.23	1.71	2.19
Type V Column Rotation Limits	4.50	0.29	1.46	1.97	2.46
Type V Column Shear Failure	2.82	0.34	0.86	1.22	1.58
Type V Column Axial Capacity	4.05	0.37	1.18	1.73	2.31
Service Chase Roof Slab Flexure	3.99	0.43	1.08	1.68	2.35
Exterior Girder Flexure	4.75	0.45	1.25	1.99	2.83
Interior Girder Flexure	5.81	0.41	1.61	2.46	3.39
Interior Girder Shear Tension	4.30	0.50	1.06	1.78	2.63
Interior Girder on GL8	4.30	0.53	1.02	1.77	2.67
Exterior Girder Shear	3.80	0.53	0.91	1.56	2.36
Floor Slab Flexure	4.34	0.35	1.30	1.87	2.45
Floor Slab Punching Shear	4.10	0.30	1.31	1.79	2.26
Average (pga)			1.19	1.79	2.46

Computation of probabilistic demand is primarily the task of a collaboration led by Los Alamos National Laboratory (Nathan Yost) with support from SC Solutions (Ben Kosbab) and Idaho National Engineering Laboratory (Robert Spears).

1.4 COMPUTATION OF STRUCTURAL FRAGILITIES

Structural fragilities for each of the components deemed to be contributors to breech of confinement by previous analysis are listed in Table 1. Each of these failure modes will be reviewed in detail and updated to account for potential structural upgrades. For example, the median FS (above ground motions with AFE = 4x10-4/year) for the interior roof girders in both shear and flexure will be modified to account for the carbon fiber wrapping that has been installed since 2010.

A simplified systems model similar to those produced in 2010 will be developed to account for the overall breech of confinement event. For example, the failure modes of excessive lateral displacement in Costantino and Associates (2013) was attributed to either excessive drift in either a column or a shear wall could control the lateral failure mode. For vertical failure modes that would lead to loss of a

[2] Carl J. Costantino and Associates, "PF-4 Nonlinear Analysis and Fragility Evaluation," for Los Alamos National Laboratory, Document ID CJC-PF4-010, Rev.1, Spring Valley, NY, September, 2013.

portion of the roof a combination of both column failure, girder failure, and roof slab failure could be constructed.

Updating of the component and system level fragilities is led by Los Alamos National Laboratory (Michael Salmon) with support from SC Solutions (Ben Kosbab), Simpson Gumpertz and Heger (Mohamed Talaat) and Idaho National Laboratory.

1.5 COMPUTATION OF SEISMIC PERFORMANCE

Distributions of both demand (from Section 1.3) and capacity (section 1.4) will be available at each of the ground motion levels used in the simulation. For each of these ground motion levels the probability of failure, conditioned on a given spectral acceleration value occurring, will be computed and a corresponding conditional cumulative density function will be fit to the calculated mean fragility points. This will result in a component level fragility that implicitly accounts for the nonlinear structural response.

The resulting performance will be computed by convolving the mean fragility curve component level fragility with the seismic hazard for the same spectral acceleration ordinate.

The probability of unacceptable performance (failure), P_F , is determined by either Equations 1 or 2:

$$P_f = - \int_0^\infty \left(\frac{dH(a)}{da}\right) P_{F|a}(a) da \qquad (1)$$

Or

$$P_f = \int_0^\infty H(a) \left(\frac{dP_{F|a}(a)}{da}\right) da \qquad (2)$$

where H(a) is the mean annual frequency of exceedance of ground motion level "a", as defined in the seismic hazard curve $P_{F|a}\,(a)$is the cumulative conditional density function that defines the probability of unacceptable performance given the ground motion level "a". H(a) and $P_{F|a}\,(a)$ represent the seismic hazard and fragility curves, respectively. The seismic fragility curves are most often expressed as a lognormal distribution. The mean seismic fragility is given by:

$$P_{F|a}(a) = \Phi\left[\frac{\ln(a/\check{A})}{\beta_C}\right] \qquad (3)$$

Where Φ ( ) is the standard Gaussian cumulative distribution function, $\check{A}$ is the median ground acceleration capacity, and β_C is the composite, or total variability,

$$\beta_C = \sqrt{\beta_R^2 + \beta_U^2} \qquad (4)$$

In the above model β_R and β_U are logarithmic standard deviations and represent the inherent randomness and uncertainty about the median value. The use of β_C and $\check{A}$ provides a single "best estimate" fragility curve and does not explicitly separate out uncertainty from underlying randomness.

Typically the fragility parameters $\check{A}$, β_R and β_C are derived as the product of a number of factors of safety on both capacity and demand. The factors of safety are calculated at a known ground motion level, and it is assumed that the fragility parameters are relatively insensitive to the selected ground motion level. This assumption may not be valid for PF-4 as nonlinear soil behavior or nonlinear structure behavior may affect demand in structural elements. The influence of nonlinear behaviors is one aspect that will be investigated in the project.

Alternate methods for computation of system performance have been advanced through the PEGASOS Refinement Project[3]. Traditionally the seismic demand at various hazard levels has been defined by Uniform Hazard Response spectra (UHRS). The annual likelihood of exceeding any acceleration defined at various spectral periods on the uniform hazard response spectra is the same. UHRS are typically defined at annual frequencies of exceedance of 10^{-4}/yr, 10^{-5}/yr, and 10^{-6} per year. Some projects calculate UHRS at annual frequencies of exceedance as low as 10^{-7}/yr. The Uniform Hazard Spectrum represent an envelope of spectra from multiple earthquakes. Rather than using this traditional approach, The PEGASOS Refinement Project used Scenario spectra for individual earthquakes in the probabilistic risk assessment. Magnitude and distance for the scenarios were based on the modes of the magnitude-distance deaggregations. The scenario spectra, also called conditional mean spectra, account for the correlation of the ground motion variability between different spectral periods. The project will look at the costs and benefits associated with the use of scenario spectra and will present recommendations for the overall performance assessment early in the project timeline.

Calculation of the component level and system level performance is led by Los Alamos National Laboratory (Michael Salmon) with support from SC Solutions (Ben Kosbab) and Idaho National Laboratory.

1.6 Related Projects

There are two related projects that support the PF-4 Performance Reassessment. Each of these projects is discussed very briefly below. The purpose of the time histories project is to define acceptable methodology to be used in subsequent selection of records for use in the P-SPRaP. The purpose of the column capitals test program is to gain further insight into the seismic behavior of unreinforced column capitals similar to those in PF-4 and to collect test data for use in validating numerical models of those columns.

1.6.1 Development of Time Histories Project

Earthquake time histories will be generated to be used as input to the probabilistic simulations. Methods used to select and condition actual earthquake records are being investigated to support development of time histories for later use in the simulations.

Earthquake time histories or accelerograms will be used as input to the nonlinear dynamic response analysis at each of the selected ground motion levels. An example of a typical time history is shown on

[3] Renault, Philippe L.A, Abrahamson, Norman A., "Probabilistic Seismic Hazard Analysis for Swiss Nuclear Power Plant Site," Volume 5, SP5 –Scenario Earthquakes, 12/17/2015

the attached Figure 2. This record that has been heavily conditioned to approximate the uniform hazard response spectra appropriate for TA-55.

In past probabilistic response analyses time histories were developed from actual earthquake records and were heavily conditioned so that the resulting response spectra closely match a target uniform hazard spectra at a given annual frequency of exceedance. Random variables were assigned to each pair of horizontal ground motions in a time history set so that directional variability was preserved. Although this method preserves directional variability, it also results in some records that are very conservative when compared to the mean uniform hazard. Figure 3 is an example of a particular horizontal record that was conditioned and then amplified to produce a very conservative spectra. In this case the resulting conditioned record used in the analysis exceeds the target uniform hazard response spectra over all frequency ranges by a factor of about 1.2.

LANL is investigating the potential systematic bias in this method of time history conditioning and will present results of that project to support the PF-4 Seismic Performance Reassessment. Preliminary results are now available[4]

1.6.2 Unreinforced Column Capitals Test Project

Reinforced concrete columns support the first floor of the laboratory. A large number of the columns have unreinforced circular capitals. Previous analysis have questioned the ability of the unreinforced portion of the capital to remain intact and to not spall during cyclic moment reversals that may be caused during strong ground shaking.

In a follow on study sponsored by the NNSA[5] a panel of seismic experts made the following observations concerning the unreinforced column capitals.

- “We believe that it would be prudent to perform limited laboratory testing of column capitals representative of those found in PF-4. We all agree that the Type V captured columns are the most critical and should, at a minimum, form a prototype for such tests. Results from a properly designed test program, in conjunction with the CJC and SGH evaluations performed to date, will allow LANL to determine whether column capital retrofit is required to reliably and conservatively meet their earthquake performance objectives. If the tests show unacceptable performance, specimens could be retrofitted and retested to validate any proposed strengthening”
- “Section 4.4 of this report describes the SGH assessment of the column capitals that support the laboratory floor slab. A sample capital is shown in Figure 3.1a. The integrity of the column capitals is critical to the support of the laboratory floor under gravity loadings; the loss of the capitals, for whatever reason, will sufficiently reduce the punching shear perimeter of the slab to trigger a local collapse. The column capitals are not reinforced, as would be routine practice

[4] Yost, Lee, Salmon, “Methodology Comparison for Selecting and Conditioning Earthquake Records for Use in Nonlinear Response History Analysis of PF-4,” Rev. B, Draft, Los Alamos National Laboratory, June 11, 2018.

[5] Kennedy, R.P, McDonald, B, Morgan, T., Whittaker, A., and Wyllie, L, “Independent Review of Seismic Performance Assessments for the Plutonium Facility, PF-4,” Los Alamos National Laboratory, Los Alamos, NM, 3/31/2015.

today. Their integrity as a continuum of concrete cannot be guaranteed in the event of design basis shaking because there are no test data available from which to either judge likely performance in the event of design basis shaking or validate numerical tools with sufficient confidence to accurately predict performance."

- "We recommend that representative slab-capital-column systems be physically tested to simulate gravity and earthquake effects. As a minimum, a sufficient number of tests should be performed, at or near full scale, to characterize the performance of the Type V slab-capital-column assemblies in PF-4. The testing program should provide the raw data and metadata needed to validate numerical models to the standard expected in the nuclear industry, represented here by ASME guidelines (ASME 2006). Earthquake shaking effects of at least 200% DBE shaking should be imposed on the test specimens to enable development of fragility functions for possible later use in a probabilistic risk assessment. If the specimens are badly damaged for the effects of 200% DBE shaking or less, retrofit strategies should be developed and implemented on virgin specimens to help guide Los Alamos National Laboratory (LANL) decision-making. It is expected that fiber-reinforced polymer (FRP) solutions would be most appropriate for strengthening the column capitals—likely similar to the details used to date to retrofit columns in PF-4. Each test should be run through failure, regardless of whether the specimens represent the as-built condition or a retrofitted condition. These studies are considered *prudent*."
- "The column capitals at the tops of the columns supporting the laboratory floor slab are unreinforced and there is very limited test data on their integrity during severe horizontal and vertical earthquake shaking. Figure 1.4a and Figure 1.4b present sections through two of the unreinforced capitals. Failure of the unreinforced capitals would likely lead to punching shear failure of the floor slabs under gravity loads and so their integrity must be maintained."

In response LANL has funded a column capital testing program with the University of Nevada, Reno. The objective of the test program is to determine, via full scale testing, the seismic vulnerability of slabs, capitals and columns that support the laboratory floor and roof girders of PF-4. Test results will inform LANL, DOE and the DNFSB of the seismic vulnerability of this type of non-ductile construction. Data will be collected from the testing program to also enable the development by others of a) validated numerical models, b) macro-models suitable for nonlinear dynamic analysis, c) failure surfaces for slab-capital-column connections, and d) fragilities functions that define the probability of failure given various multiples of DBE shaking. Results of the test program support the PF-4 Seismic Performance Reassessment.

2 Roles of Integrated Project Team Members

The following roles are adapted for the execution of this project.

1. **<u>NNSA Program Management.</u>** The NNSA Program Manager (CDNS) reports to the Chief , Defense Nuclear Safety who is providing overall funding and oversight to the project. The NNSA Program Manager receives independent advice directly from the NNSA Technical Advisory Committee and from the Independent Peer Review Panel

2. **Project Management Committee.** The Project Management Committee is responsible for overall technical direction, guidance, and collaborative management of the project. The Project Management Committee will obtain consensus on technical approaches to be used during project execution with input from the advisory committee, independent consultants and project team members as needed during project execution. The Project Management Committee will obtain consensus on technical approaches, personnel, and other project matters that may deviate from this charter. The Project Management Committee includes representatives from each of the major organizations executing project work. This includes representatives from Idaho National Laboratory, Los Alamos National Laboratory, and SC Solutions. The Program Management Committee holds weekly teleconferences to discuss status, and emerging technical issues as needed during project execution. The Program Management Committee will invite members from NNSA Program Management and NNSA technical advisory committee as needed.
3. **Project Administration Committee.** The Project Administration Committee consists of individuals who will provide oversight and guidance on administrative matters such as security, procurement activities, quality assurance, cost and schedule, and administration of subcontracts.
4. **Project Administrative Assistant (AA**). The administrative assistant provides project support as appropriate. The AA coordinates for site badging (if needed), reservations for meeting rooms and sundries as requested by the Administrative Subcontract Technical Representative (AdSTR) or Project Engineer (PE), and coordinate other activities as requested by the Project Management Committee or AdSTR. The administrative assistant checks the subcontract field file (SFF) for completeness of required documents. The admininstrative assistant maintains the project field file, and is responsible for distribution of project documents.
5. **Independent Peer Review Panel (PRP)**. The independent peer review panel provides independent technical oversight of all aspects of the project and reports directly to the NNSA Program Manager. The PRP will issue findings and comments on technical products at key milestones in the project and will also review project deliverables. The PRP will produce a report that describes their involvement in the project from the kickoff meeting and will provide an opinion on the overall quality of project results at project completion. Independent peer review of SDC 3 and above projects is required by DOE-STD-1020-2016, and ASCE-4.
6. **Project Advisory Committee (PAC)** The project advisory committee consists of a panel of seismic experts who are familiar with the previous work and who will support the project management committee directly by providing technical advice. They do not fulfill the role of independent reviewers. The project advisory committee may also seek to reach out to the primary authors of previous work on PF-4 to include Greg Mertz (SGH) and Said Bolourchi or Andrew Sarawit (SGH) for clarification on previous results.
7. **Procurement Specialist (PS)**, also known as the Subcontract Administrator (SA) – is the generic term for an ASM individual who: (1) has been delegated Procurement Authority by the ASM-DL to subcontract for authorized supplies and services on behalf of LANS, and (2) is responsible for the solicitation, negotiation, award, and administration of subcontracts. This generic term includes such titles as Contract Administrator, Buyer, Subcontract Administrator, etc. Only a Procurement Specialist (PS) acting within the scope of their delegated procurement authority

(See AP 1012, Delegation of Procurement Authority) is empowered to authorize changed work (issue a Directed Change Order) and execute subcontract modifications on behalf of LANS

The Procurement Specialist with the AdSTR to ensure that both LANS and the subcontractor comply with the terms and conditions of the subcontract. The PS is the only individual authorized by LANS to direct the subcontractor to deviate from the express, written terms of the subcontract

8. **Administrative Subcontract Technical Representative (AdSTR)** - The subcontract technical representative is the point of contact for all of the technical aspects of the subcontract and is responsible for Technical Oversight of a subcontractor's performance under a subcontract. The subcontract technical representative is also responsible for progress monitoring and reporting of the subcontractor's operations during performance of the subcontract. The AdSTR is responsible for invoice review and approval, records retention, and processing of contract change with the PS. The subcontract technical representative is not authorized to make any commitments on behalf of LANS or changes to the terms and conditions of a subcontract

9. **Quality Assurance Representative (QAR)** – the quality assurance representative is responsible for administering the quality assurance requirement communicated in the contract Exhibit H. The QAR will schedule and coordinate source verification of the acceptance of qualification of personnel, equipment, calibration, test model setup, test model material, and test methods. The QAR will coordinate the compilation of the commercial grade dedication package (CGD) with assistance from the PE and TSMEs as needed.

10. **Task Leads** – Task leads for each of the major tasks are identified in bold under each task. Task leads are responsible for oversight and technical direction of the major subtasks. Leading the SSI model development are Ben Kosbab (SC Solutions) with the assistance of Justin Coleman at Idaho National Laboratory. Ben Kosbab (SC Solutions) will also lead the computation of probabilistic demand with assistance from Los Alamos National Laboratory. The majority of the simulations and data reduction for the probabilistic demand will be done using the High Performance Computing Network, a secure computing environment, at Los Alamos. Nathan Yost will be directing the probabilistic simulations on LANL's High Performance Computing Network and will be the point of contact for software quality procedures. Leading the computation of structural fragilities will be Michael Salmon of Los Alamos National Laboratory with primary assistance from Simpson Gumpertz and Heger, and SC Solutions. Los Alamos National Laboratory. Leading the performance computation for the reassessment will be Mr. Michael Salmon of Los Alamos National Laboratory with assistance from SGH.

3 Named Individuals

The following assignments to the roles described above are made for the duration of the project.

Subcontract Administrator – Charles Gibson, 505-665-4177, cegibson@lanl.gov

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4 External Review/Oversight

Both the National Nuclear Security Administration (NNSA), Office of Chief Of Nuclear Safety, and the Defense Nuclear Facilities Safety Board have an interest in the results of the testing program and the implication to safety of TA-55 – PF-4 and will participate as observers during project execution.

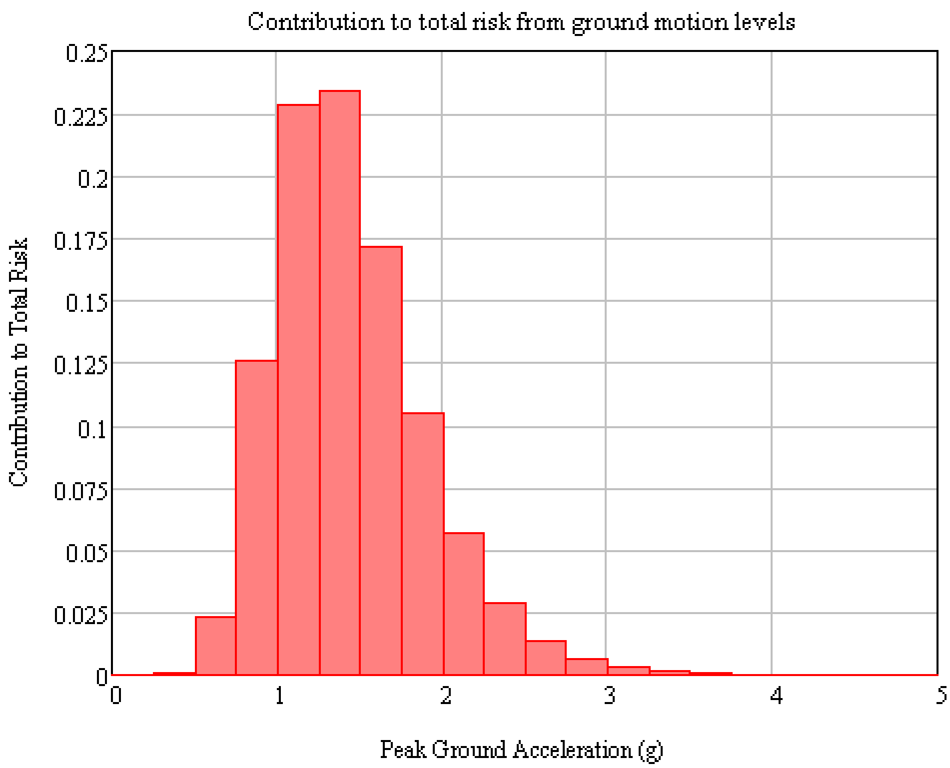


Figure 1
Contribution to Total Risk from Various Ground Motion Bins

TA-55/CMRR Envelope Hazard, $\check{A}$ = 1.85g (pga), β_C = 0.32

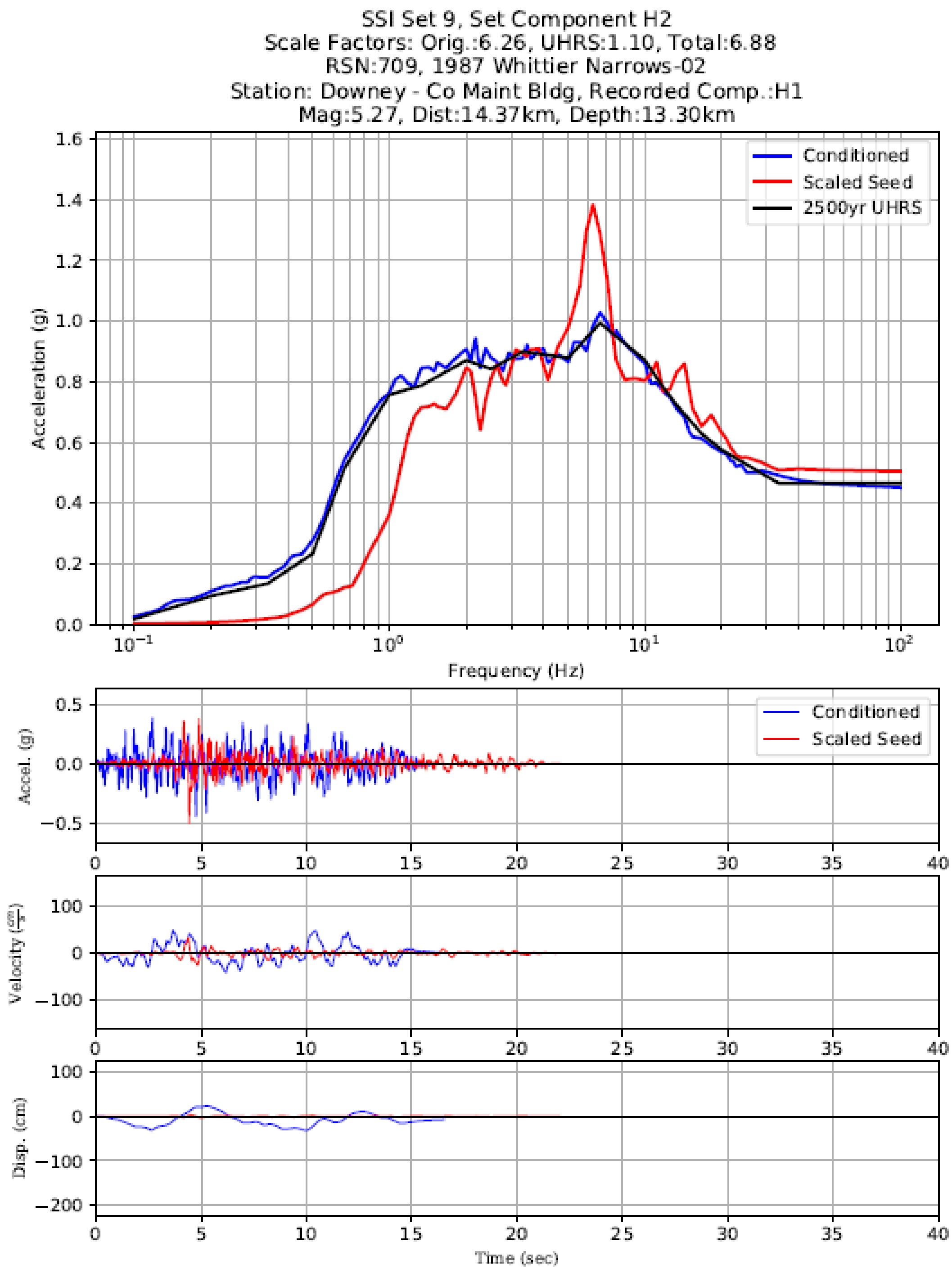


Figure 2
Typical Time History used in Probabilistic Analysis

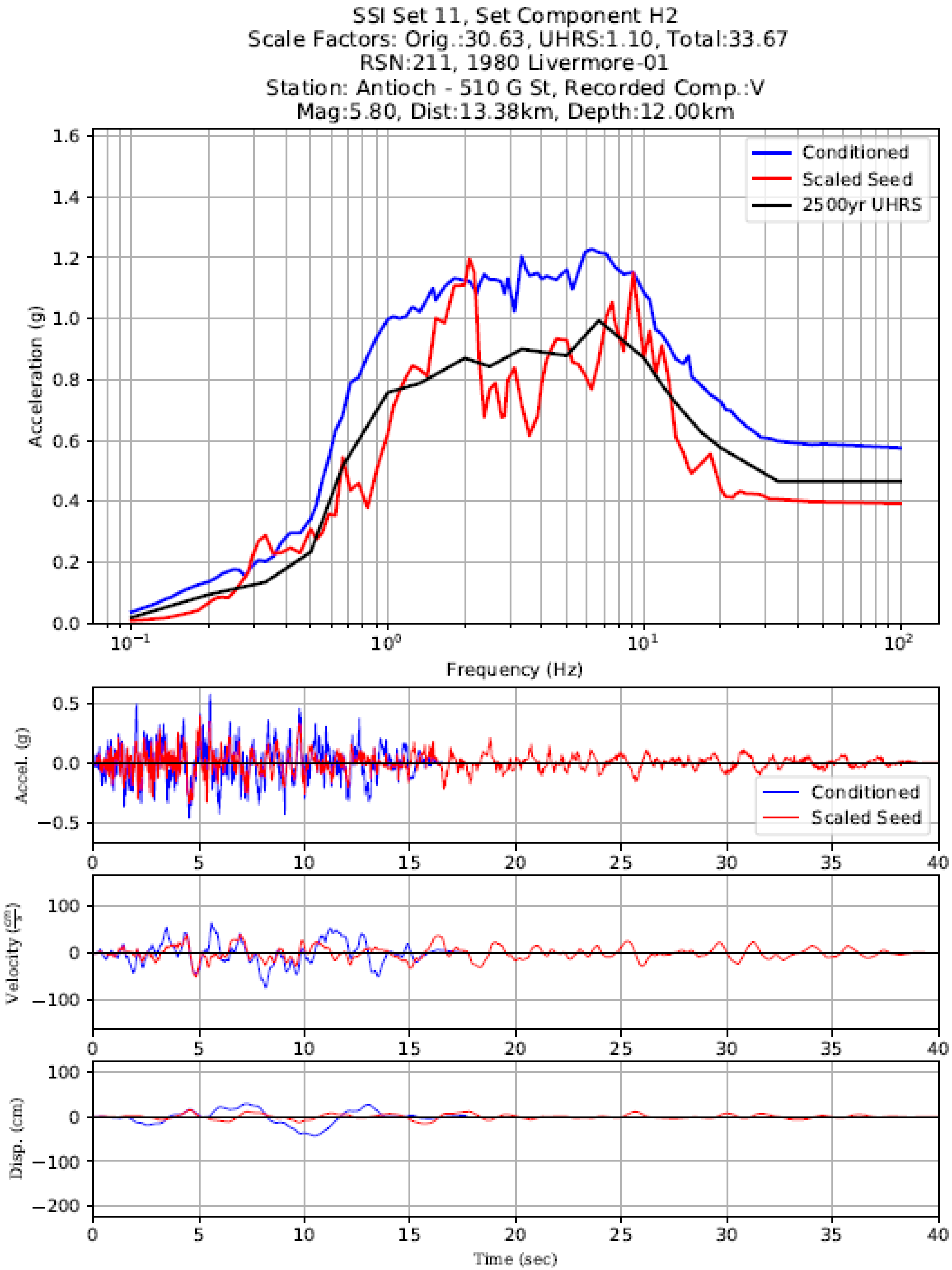
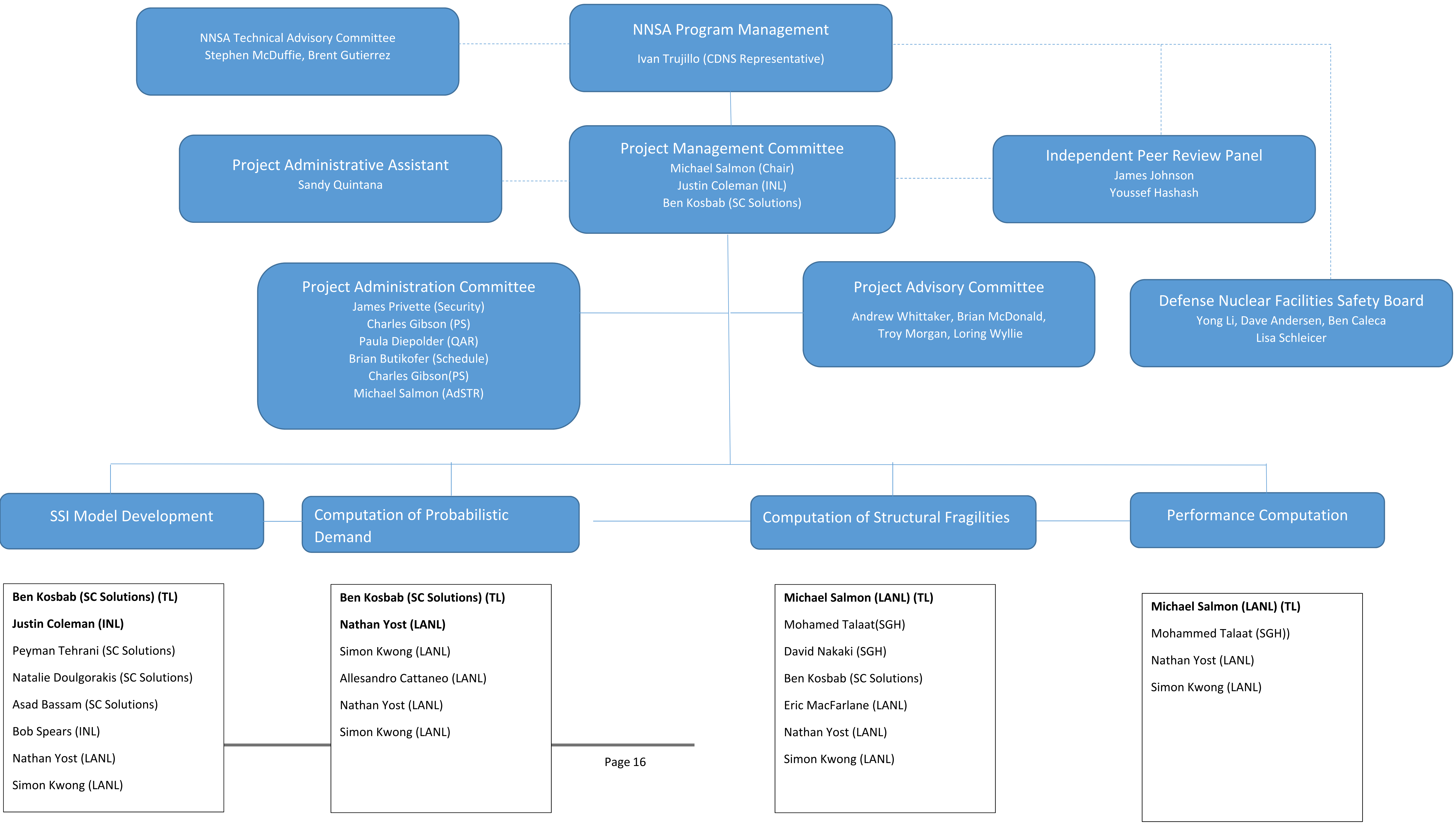


Figure 3
Example of Conservative Conditioned Spectra

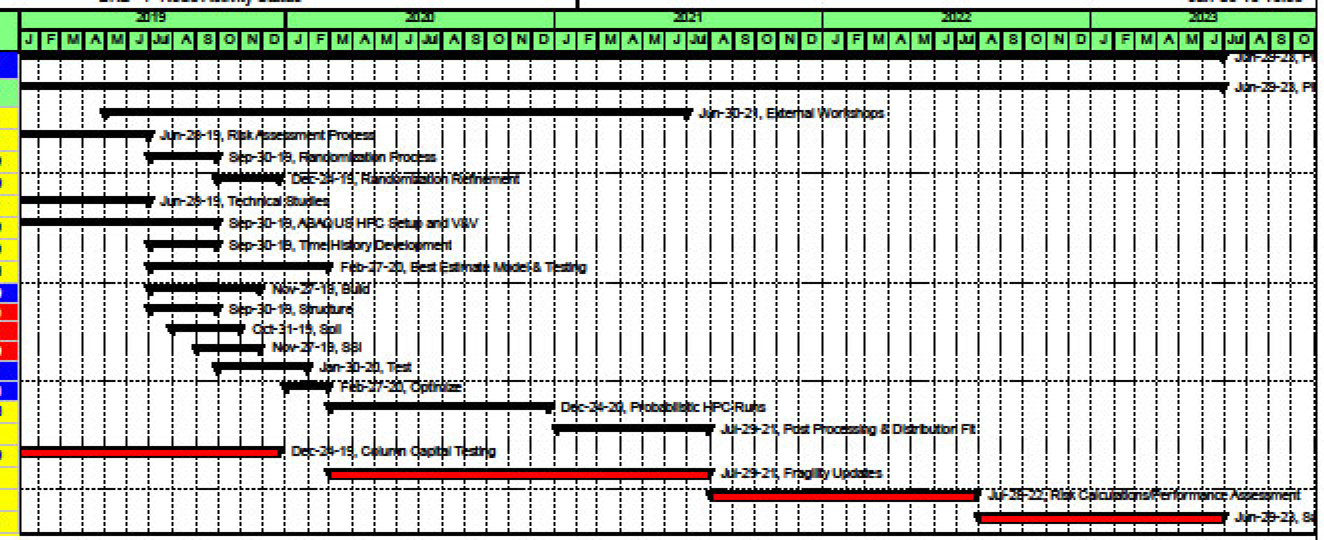
Attachment 1 – Project Organization


NNSA Technical Advisory Committee
Stephen McDuffie, Brent Gutierrez
NNSA Program Management
Ivan Trujillo (CDNS Representative)
Project Administrative Assistant
Sandy Quintana
Project Management Committee
Michael Salmon (Chair)
Justin Coleman (INL)
Ben Kosbab (SC Solutions)
Independent Peer Review Panel
James Johnson
Youssef Hashash
Project Administration Committee
James Privette (Security)
Charles Gibson (PS)
Paula Diepolder (QAR)
Brian Butikofer (Schedule)
Charles Gibson(PS)
Michael Salmon (AdSTR)
Project Advisory Committee
Andrew Whittaker, Brian McDonald,
Troy Morgan, Loring Wyllie
Defense Nuclear Facilities Safety Board
Yong Li, Dave Andersen, Ben Caleca
Lisa Schleicer
SSI Model Development
Computation of Probabilistic Demand
Computation of Structural Fragilities
Performance Computation
Ben Kosbab (SC Solutions) (TL)
Justin Coleman (INL)
Peyman Tehrani (SC Solutions)
Natalie Doulgorakis (SC Solutions)
Asad Bassam (SC Solutions)
Bob Spears (INL)
Nathan Yost (LANL)
Simon Kwong (LANL)
Ben Kosbab (SC Solutions) (TL)
Nathan Yost (LANL)
Simon Kwong (LANL)
Allesandro Cattaneo (LANL)
Nathan Yost (LANL)
Simon Kwong (LANL)
Michael Salmon (LANL) (TL)
Mohamed Talaat(SGH)
David Nakaki (SGH)
Ben Kosbab (SC Solutions)
Eric MacFarlane (LANL)
Nathan Yost (LANL)
Simon Kwong (LANL)
Michael Salmon (LANL) (TL)
Mohammed Talaat (SGH))
Nathan Yost (LANL)
Simon Kwong (LANL)

Attachment 2 – Schedule

PF-4 Initial Planning Schedule | BKB - P-Node Activity Status | Jan-08-19 15:55

Activity ID	Activity Name	Original Duration	Start	Finish
	PF-4 Initial Planning Schedule	1004.7d	Jan-02-19	Jun-29-23
	PF-4	1004.7d	Jan-02-19	Jun-29-23
	External Workshops	483.1d	Apr-30-19	Jun-30-21
	Risk Assessment Process	112.6d	Jan-02-19	Jun-28-19
	Randomization Process	56.3d	Jul-01-19	Sep-30-19
	Randomization Refinement	52.4d	Oct-01-19	Dec-24-19
	Technical Studies	112.6d	Jan-02-19	Jun-28-19
	ABAQUS HPC Setup and V&V	168.9d	Jan-02-19	Sep-30-19
	Time History Development	56.3d	Jul-01-19	Sep-30-19
	Best Estimate Model & Testing	145.3d	Jul-01-19	Feb-27-20
	Build	93.9d	Jul-01-19	Nov-27-19
	Structure	56.3d	Jul-01-19	Sep-30-19
	Soil	57.1d	Aug-01-19	Oct-31-19
	SSI	54.9d	Sep-03-19	Nov-27-19
	Test	70.6d	Oct-01-19	Jan-30-20
	Optimize	36.3d	Jan-02-20	Feb-27-20
	Probabilistic HPC Runs	186.8d	Mar-02-20	Dec-24-20
	Post Processing & Distribution Fit	132.3d	Jan-04-21	Jul-29-21
	Column Capital Testing	221.3d	Jan-02-19	Dec-24-19
	Fragility Updates	318.7d	Mar-02-20	Jul-29-21
	Risk Calculations/Performance Assessment	222.2d	Aug-02-21	Jul-28-22
	Safety Basis Assessment	205.4d	Aug-01-22	Jun-29-23



Remaining Level of Effort | Actual Work | Critical Remaining Work | Baseline Milestone
Actual Level of Effort | Remaining Work | Primary Baseline | Milestone

Page 1 of 1

TASK filters: Deleted Activities, NOT COMPLETE, PF-4 Only.

WBS Dictionary

Number: PF-4.1.1.1	Name: **External Workshops**	Owner: PM Committee
Description:	Face-to-face meetings between broader project team members and other stakeholders at key technical junctures of the project. Each workshop to have specific focus topics identified corresponding to project activities and/or deliverables per the WBS.	
Deliverables:	Project Status Presentation (before), and Meeting Minutes (after)	
Approvals:	PM Committee, Peer Reviewers, CDNS Representative	

Number: PF-4.1.2	Name: **Risk Assessment Process**	Owner: Mike Salmon
Description:	Lay out and demonstrate through an example the framework for the risk assessment process that will be used to estimate seismic performance of PF-4 using probabilistic response history analysis and component fragility functions. The methodology will result in a calculated annual probability of failure for comparison to target performance goal. Will address the seismic intensity measures and engineering demand parameters to use, selecting ground motion level(s) of interest, number of simulations needed to achieve target confidence level, and limit states to consider.	
Deliverables:	Topical report with framework, implementation details, and tested example using simulated data	
Approvals:	PM Committee, Peer Reviewers, CDNS Representative	

Number: PF-4.1.3	Name: **Randomization Process**	Owner: Mike Salmon
Description:	Identify each random variable (RV) to potentially consider in probabilistic response history analysis, within the context of the risk assessment process, their statistical distribution parameters, and sampling routine. RVs to include those related to ground motion, soil properties, structure properties, and inelastic behavior.	
Deliverables:	Topical report with identification and description of each potential RV and its distirbution	
Approvals:	PM Committee, Peer Reviewers	

Number: PF4.1.4	Name: **Randomization Refinement**	Owner: Ben Kosbab
Description:	Evaluate the relative importance of each potential RV identified as it relates to mean and variability of seismic performance (i.e. tornado plot or similar); identify the top RVs for inclusion in probabilistic analysis; finalize RV sampling plan for probabilistic analysis.	
Deliverables:	Topical report describing the selection of RVs to include in probabilistic analysis	
Approvals:	PM Committee, Peer Reviewers	

Number: PF-4.1.5	Name: **Technical Studies**	Owner: Ben Kosbab
Description:	Perform analytical studies to develop technical bases for modeling scope and/or approach of various soil, structure, ground motion, and risk assessment topics. Each study to use simplified data and methods to assess the relative significance of the technical topic on project goal, and the relative effect of different approaches on the resulting seismic performance estimate.	

Deliverables:	Technical report for each study providing the scope/approach recommendation and its basis
Approvals:	PM Committee, Peer Reviewers, Project Advisors

Number: PF 4.1.6	Name: **ABAQUS HPC Setup and V&V**	Owner: Nathan Yost
Description:	Establish and test capability to perform ABAQUS nonlinear response history analysis on HPC hardware and software at LANL. Implement ABAQUS software V&V to allow NQA performance of such analysis. Interface with project QA personnel to ensure sufficiency of V&V program	
Deliverables:	Technical report with sample model analysis results from LANL compared to same analysis performed elsewhere. Approved ABAQUS V&V package for LANL NQA program.	
Approvals:	PM Committee, Project QA representative.	

Number: PF-4.1.7	Name: **Time History Development**	Owner: Mike Salmon/Richard Leee
Description:	Develop a suite of ground motion records compatible with the site hazard and the risk assessment process of the project for use in probabilistic nonlinear response history analysis.	
Deliverables:	Technical report summarizing the suite of ground motions, with corresponding engineering calculations containing specific details and documentation	
Approvals:	PM Committee, Peer Reviewers, CDNS Representative	

Number: PF-4.1.8	Name: **Best Estimate Model and Testing**	Owner: Ben Kosbab
Description:	Develop and test the soil-structure interaction model in ABAQUS for nonlinear response history analysis of PF-4 with best estimate (median-centered) properties, capable of generating realistic seismic demands corresponding to limit states of interest to risk assessment, and optimized for running efficiently on LANL HPC cluster(s).	
Deliverables:	Technical report summarizing the model development, testing, and optimization, with corresponding engineering calculations containing specific details and documentation	
Approvals:	PM Committee, Peer Reviewers, Project Advisors, CDNS Representative	

Number: PF-4.1.9	Name: **Probabilistic HPC Runs**	Owner: Mike Salmon
Description:	Generate randomized versions of the best estimate model following the randomization refinement recommendations. Analyze the randomized models for the suite of ground motions developed. Extract, save, and catalogue the output data needed to quantify the selected engineering demand parameters corresponding to the limit states of interest.	
Deliverables:	Technical report summarizing the generation and analysis of randomized models, with corresponding engineering calculations containing specific details and documentation	
Approvals:	PM Committee, Peer Reviewers	

Number: PF-4.1.10	Name: **Post-Processing and Distribution Fit**	Owner: Mike Salmon
Description:	Post-process the output data from the probabilistic analysis runs and aggregate together to develop probabilistic distributions for each engineering demand parameter for use in seismic performance assessment of the facility.	
Deliverables:	Technical report summarizing the resulting distributions, with corresponding engineering calculations containing specific details and documentation	

Approvals:	PM Committee, Peer Reviewers, Project Advisors, CDNS Representative

Number: PF4.1.11	Name: **Column Capital Testing**	Owner: Eric MacFarlane
Description:	Interface activity with parallel project performing physical testing of unreinforced column capitals representative of those at PF-4. Results of testing to be used to update fragility functions of these elements. Column capital testing is not intended to inform the global modeling of PF-4 for demand analysis.	
Deliverables:	Technical reports summarizing the testing program and its results	
Approvals:	Mike Salmon, CDNS Representative, Project Advisors	

Number: PF-4.1.12	Name: **Fragility Updates**	Owner: Mike Salmon
Description:	Assess existing fragility functions for structural components of PF-4 to determine whether updates are needed to align with the risk assessment process, and/or to incorporate additional information.	
Deliverables:	Technical report summarizing the fragility of each structural component, with corresponding engineering calculations for each updated component	
Approvals:	PM Committee, Peer Reviewers, CDNS Representative	

Number: PF-4.1.13	Name: **Risk Calculation / Performance Assessment**	Owner: Mike Salmon
Description:	Integrate seismic demand from probabilistic nonlinear response history analysis results with fragility functions for structural components, following the project risk assessment process, to calculate seismic performance and compare to target performance goal.	
Deliverables:	Technical report with corresponding engineering calculations	
Approvals:	PM Committee, Peer Reviewers, CDNS Representative	

Number: PF-4.1.14	Name: **Safety Basis Assessment**	Owner: Mike Salmon
Description:	Use seismic performance assessment of PF-4 to update the safety basis for the facility reflecting modern seismic hazard estimates	
Deliverables:	Technical report with corresponding engineering calculations	
Approvals:	CDNS Representative	